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Journal of Alloys and Compounds 250 (1997) 471–481

Journal of ALLOYS AND COMPOUNDS

Rare-earth metal prices in the USA ca. 1960 to 1994

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Abstract

Rare-earth metal prices were compiled from the late 1950s and early 1960s through 1994. Although commercial demand for rare-earth metals began in 1908, as the alloy mischmetal, commercial quantities of a wide range of individual rare-earth metals were not available until the late 1950s.

The discovery of a large, high-grade rare-earth deposit at Mountain Pass, CA, USA, in 1949, was significant because it led to the production of commercial quantities of rare-earth elements that reduced prices and encouraged wider application of the materials.

The availability of ore from Mountain Pass, and other large rare-earth deposits, especially those in Australia and China, has provided the world with abundant resources for rare-earth metal production. This availability, coupled with improved technology from Government and private-sector metallurgical research, has resulted in substantial decreases in rare-earth metal prices since the late 1950s and early 1960s.

Price series for the individual rare-earth metals (except promethium) are quoted on a kilogram basis from the late 1950s and early 1960s through 1994. Prices are given in US dollars on an actual and constant dollar basis. Industrial and economic factors affecting prices during this time period are examined.

Keywords: Rare-earth metals; Prices; Economics; Metals; History

1. Introduction

Prices of commercial quantities of a complete range of rare-earth metals were first quoted in the USA in the late 1950s and early 1960s. Rare-earth prices decreased considerably as availability and extraction technology improved. There were many advances in separation technology and metallurgical methods after the time when Swedish chemist and mineralogist Carl Gustav Mosander first prepared metallic cerium in 1827 until these materials were no longer considered 'rare'.

The rare earths are defined as the 17 elements composed of scandium, yttrium, and the 15 lanthanides [1].

2. Metal history

Mosander prepared the first rare-earth metal by reducing cerous chloride with potassium in a hydrogen atmosphere to produce an impure powdered metal [2]. Later, Beringer in 1842, de Marginac in 1853, and Wöhler in 1867, used sodium to reduce cerous chloride.

In 1875, Hillebrand and Norton were successful in producing cerium, lanthanum, and didymium metals by electrolysis of molten rare-earth halides [3]. Subsequent work by Muthmann, Hofer, and Weiss in 1902, Hirsch in 1911, and Kremers and Stevens in 1923 contributed to electrowinning other rare-earth metals. Billy and Trombe improved on the electrolytic method in the 1930s by producing a 'higher purity' product [4]. In the early 1950s, Gray was believed to be the first to exclude air and moisture in the electrowinning cell, using an argon atmosphere to produce cerium metal from cerium dioxide dissolved in an electrolyte.

In 1942, researchers at the Ames Laboratory of Iowa State University used calciothermic reduction to produce metal from anhydrous rare-earth chlorides.

3. Separation history

Technological advances in separation technology has reduced rare-earth metal prices by reducing production costs and increasing efficiency. Separation techniques can be broadly classified into two groups: classical methods and modern methods [5]. The classical methods include fractional crystallization, selective (fractional) precipita-

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0925-8388/97/$17.00
PII S0925-8388(96)02532-7

tion, and thermal reactions. Commercial refining continues to use some of these methods to produce rare earths. The modern methods, ion-exchange and solvent extraction (liquid–liquid), are responsible for substantially reducing separation costs and ultimately the cost of the rare-earth metals.

Separation technology to produce kilogram and greater quantities became available when ion-exchange (IX) research from the Manhattan Project was released in 1947 (see references cited in Ref. [6]). Subsequent work by Spedding and others at the Ames Laboratory improved the IX process. Commercial use of IX to produce rare earths was used extensively in the USA beginning in the 1950s.

Solvent extraction (SX) was first studied by Fischer et al. in 1937 [7]. By 1941, Appleton and Selwood added to the literature by separating rare-earth thiocyanates with water and butanol (butyl alcohol) [8]. Templeton and Peterson subsequently separated rare-earth nitrates between an aqueous phase and hexanol [9,10]. By 1950, Asselin et al. advanced the idea of using solvent extraction for separating individual rare earths [11]. Choppin and Silva, and Smith and Hoffman greatly enhanced the SX method by presenting improved eluting anions that formed complex ions with rare-earth cations [12,13]. Owing to its cost efficiency in large-scale rare-earth refining, SX has become the world's leading commercial separation technique.

Warf, in 1949, advanced the earlier work of Imre (1927) by demonstrating that tri-*n*-butyl phosphate (TBP) was superior to diethyl ether in extracting Ce(IV) from the trivalent rare earths. Further research by Wylie in 1951, and by Peppard and others in 1953, greatly improved the commercial application. TBP continues to be used commercially for extracting Ce(IV) and Th(IV).

4. Production history

Commercial use of the rare-earth elements was established in 1884, when the incandescent lamp mantle industry produced mantles composed of lanthanum, yttrium, and zirconium oxides. By 1886, thorium and cerium oxide was used to create a brighter light for the newly invented incandescent gas light mantle. The inventor, Austrian chemist and metallurgist, Carl Auer von Welsbach, patented the luminescent material in 1893—a mixture of 1000 parts of thorium nitrate, ten parts of cerium nitrate, and minor amounts of other nitrates [14]. The indelible brand name placed on each mantle was made from salts of neodymium and praseodymium. However, these uses required only minor amounts of rare earths.

The first large-scale application for rare earths began in 1903, when Auer von Welsbach patented a pyrophoric alloy composed of 70% mischmetal and 30% iron [15]. Five years later, the mischmetal–iron alloy was commercially marketed in an ignition system for incandescent gas lamps. The use of the lamp mantle and mischmetal–iron alloy peaked by 1912, after which electric lighting came into general use. The alloy's use continues today as the 'flint' in disposable lighters, camping lanterns, campfire starter sticks, and the sparkers used to ignite laboratory and welding gases.

Rare-earth metals in relatively pure form were first prepared in 1931 [16]. In the 1940s some applications were found for alloying rare-earth metals with ductile iron, but significant uses were not developed until the late 1960s. The use of individual rare-earth metals remained small until the 1950s when separation and metallurgical technologies improved.

The earliest commercial source for cerium was the rare-earth and thorium phosphate mineral, monazite. World production initially came from Sweden and Norway, but the USA (1893), Brazil (1895), and India (1911) followed as larger, more economic deposits were discovered and developed [17]. In the late 1950s monazite was sourced primarily from South Africa, but additional large resources in Australia were developed in the 1960s.

The most significant event affecting the price and availability of rare-earth metals occurred with the discovery of a large rare-earth deposit at Mountain Pass, California. A light-brown heavy mineral, collected by prospectors in the vicinity of the present-day mine, was submitted to the US Bureau of Mines for identification in 1949 — that mineral was bastnasite. Subsequent mapping by geologists from the US Geological Survey in 1950 delineated the large bastnasite-bearing ore body known as the Sulphide Queen carbonatite [18]. Discovery of the high-grade carbonatite was significant because it led to the production of commercial quantities of rare-earth elements that reduced prices and encouraged wider application of the materials. Until the discovery of this deposit, the rare earths were believed to be available only at low concentration in heavy mineral sands deposits or in disseminated or small vein-type deposits. Improved knowledge of the rare-earth metals' properties has led to the development of a variety of metallurgical uses.

5. Prices

Rare-earth metal prices vary considerably depending on purity and quantity. Price fluctuations in the early 1960s to 1994 were affected primarily by supply and demand, environmental legislation, and economic factors, especially inflation and energy costs.

Declining prices for the rare-earth metals during the 1958–1971 period was a direct result of the increased supply from the Mountain Pass deposit. The period was characterized by widespread commercialization of the individual rare earths, including compounds and metals. A significant development in the late 1960s was the accept-

ance of rare-earth silicide, and later, mischmetal, as an additive in high strength low alloy (HSLA) steels [19].

From 1971–1978, the rare-earth supply continued to grow and demand kept pace. A major increase in demand for mischmetal occurred late in the period as a result of its use in steel for the Alaskan oil pipeline. Beginning in 1978, prices for the rare-earth metals were tied primarily to the US economy. 'Double digit' inflation and higher energy costs increased operating costs throughout the mining industry. Rare-earth metal prices followed the trend and began increasing in 1979 to balance higher operating costs.

After the 1981–1982 recession, as the economy improved and inflation subsided, rare-earth metal prices, for the most part, stabilized. The exception during this period was scandium. The main source of scandium at this time, the Soviet Union, ceased exports in 1984, reportedly because of internal demand for laser research. The price for scandium rose to an astronomical $75 000 per kilogram — even higher by the gram. Scandium's price decreased markedly the following year as production in the USA came on-line.

In 1985, demand for the rare earths used in petroleum fluid cracking catalysts, their principal market, dropped sharply. The rapid decline was the result of environmental legislation reducing the amount of lead allowed in gasoline. This legislation caused the refinery industry to switch to fluid cracking catalysts that used significantly lower amounts of rare earths, mainly lanthanum concentrates and rare-earth chlorides. With demand down, US mine production decreased nearly 50% in 1985. The indirect effect of this market shift was a substantial increase in rare-earth metal prices the following year.

Subsequent to the 1986 increase, rare-earth metal prices stabilized. Growth in the rare-earth industry in the period 1986–1988 was primarily in the markets for individual, high-purity products. Rare-earth metal demand in the 1986–1994 period was greatest for neodymium metal used in high-strength permanent magnet alloys. As the industry increased neodymium separation capacity to meet demand, prices decreased as a result of economy of scale. Projected growth in demand, however, is expected to outpace current installed capacity and result in future price increases.

Demand also increased in the 1990s for rare-earth metals used in nickel–hydride rechargeable batteries. The use of mischmetal (with lanthanum and other rare-earth additions) in the nickel–hydride alloys has minimized demand for individual rare-earth metals and prices were not affected through 1994.

Price series for the individual rare-earth metals (except promethium) are quoted on a kilogram basis from the late 1950s and early 1960s through 1994. Prices for promethium metal were excluded because all of its isotopes have short half-lives. Promethium metal was also not

Scandium Metal Prices[1]
(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959	NA	NA	1977[5]	6,172.94	13,925.01
1960	NA	NA	1978[5]	6,172.94	12,908.92
1961	NA	NA	1979	6,600.00	12,706.26
1962[3]	35,000.00	164,070.63	1980	7,200.00	12,662.76
1963[4]	35,000.00	162,261.03	1981	8,000.00	12,785.80
1964[5]	11,889.53	54,125.26	1982	11,000.00	16,552.51
1965[6]	10,000.00	44,401.41	1983	11,000.00	15,907.11
1966[6]	10,000.00	42,891.16	1984	75,000.00	103,928.57
1967[7]	7,936.64	33,030.05	1985	30,000.00	40,074.15
1968[7]	7,936.64	31,472.03	1986	25,000.00	32,533.54
1969[7]	7,936.64	29,964.39	1987	25,000.00	31,525.00
1970[7]	7,936.64	28,432.12	1988	25,000.00	30,341.67
1971[5]	6,172.94	20,981.35	1989[7]	21,500.00	24,987.56
1972[5]	6,172.94	20,062.07	1990[7]	12,000.00	13,355.69
1973[5]	6,172.94	18,847.65	1991[7]	8,400.00	9,007.14
1974[5]	6,172.94	17,336.48	1992[8]	10,000.00	10,430.11
1975[5]	6,172.94	15,821.30	1993[8]	10,000.00	10,210.53
1976[5]	6,172.94	14,883.52	1994[8]	10,000.00	10,000.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 1 pound metal ingot prices, 99.5+% purity, from Atomergic Chemetals, Div. of Gallard Schlesinger.

[4]Prices converted from 100-400 gram metal ingot prices, 99+% purity, from Atomergic Chemetals Co., Div. of Gallard Schlesinger.

[5]Prices converted from 1-2 pound metal ingot prices.

[6]Prices converted from 227-454 gram metal ingot prices.

[7]Prices converted from 2-10 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Yttrium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	540.00	2,659.92	1977[5]	308.65	696.25
1960[3]	540.00	2,619.00	1978[5]	308.65	645.45
1961[3]	540.00	2,589.13	1979	320.00	616.06
1962[3]	540.00	2,531.38	1980	390.00	685.90
1963[4]	716.50	3,321.73	1981	430.00	687.24
1964[5]	654.77	2,980.75	1982	430.00	647.05
1965[6]	449.74	1,996.92	1983	430.00	621.82
1966[6]	396.83	1,702.06	1984	430.00	595.86
1967[5]	352.74	1,468.00	1985	510.00	681.26
1968[5]	352.74	1,398.76	1986	510.00	663.68
1969[5]	319.67	1,206.90	1987	510.00	643.11
1970[5]	352.74	1,263.65	1988	510.00	618.97
1971[5]	308.65	1,049.07	1989[7]	510.00	592.73
1972[5]	308.65	1,003.10	1990[7]	340.00	378.41
1973[5]	308.65	942.38	1991[7]	340.00	364.57
1974[5]	308.65	866.82	1992[7]	340.00	354.62
1975[5]	308.65	791.07	1993[7]	340.00	347.16
1976[5]	308.65	744.18	1994[7]	340.00	340.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from 1-5 pound metal ingot prices.

[7]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Lanthanum Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	340.00	1,674.77	1977[5]	88.18	198.93
1960[3]	340.00	1,649.00	1978[5]	88.18	184.41
1961[3]	340.00	1,630.19	1979	108.00	207.92
1962[3]	340.00	1,593.83	1980	115.00	202.25
1963[4]	308.65	1,430.90	1981	125.00	199.78
1964[5]	160.94	732.64	1982	125.00	188.10
1965[6]	189.60	841.84	1983	125.00	180.76
1966[6]	165.35	709.19	1984	125.00	173.21
1967[5]	154.32	642.25	1985	125.00	166.98
1968[5]	154.32	611.96	1986	150.00	195.20
1969[5]	110.23	416.17	1987	150.00	189.15
1970[5]	110.23	394.89	1988	150.00	182.05
1971[5]	88.18	299.73	1989[7]	150.00	174.33
1972[5]	88.18	286.60	1990[7]	150.00	166.95
1973[5]	88.18	269.25	1991[7]	150.00	160.84
1974[5]	88.18	247.66	1992[7]	150.00	156.45
1975[5]	88.18	226.02	1993[7]	150.00	153.16
1976[5]	88.18	212.62	1994[7]	150.00	150.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from 1-5 pound metal ingot prices.

[7]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Cerium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	330.00	1,625.51	1977[5]	88.18	198.93
1960[3]	330.00	1,600.50	1978[5]	88.18	184.41
1961[3]	330.00	1,582.24	1979	108.00	207.92
1962[3]	330.00	1,546.95	1980	115.00	202.25
1963[4]	304.24	1,410.46	1981	125.00	199.78
1964[5]	160.94	732.64	1982	125.00	188.10
1965[6]	174.17	773.32	1983	125.00	180.76
1966[5]	165.35	709.19	1984	125.00	173.21
1967[5]	154.32	642.25	1985	125.00	166.98
1968[5]	154.32	611.96	1986	175.00	227.73
1969[5]	110.23	416.17	1987	175.00	220.68
1970[5]	88.18	315.91	1988	175.00	212.39
1971[5]	88.18	299.73	1989[7]	175.00	203.39
1972[5]	88.18	286.60	1990[7]	175.00	194.77
1973[5]	88.18	269.25	1991[7]	175.00	187.65
1974[5]	88.18	247.66	1992[7]	350.00	365.05
1975[5]	88.18	226.02	1993[7]	350.00	357.37
1976[5]	88.18	212.62	1994[7]	350.00	350.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from 1-5 pound metal ingot prices.

[7]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Praseodymium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	420.00	2,068.83	1977[5]	352.74	795.71
1960[3]	420.00	2,037.00	1978[5]	352.74	737.65
1961[3]	420.00	2,013.76	1979	290.00	558.31
1962[3]	420.00	1,968.85	1980	310.00	545.20
1963[4]	385.81	1,788.62	1981	310.00	495.45
1964[5]	412.26	1,876.77	1982	310.00	466.48
1965[6]	401.24	1,781.57	1983	310.00	448.29
1966[6]	407.86	1,749.34	1984	310.00	429.57
1967[5]	385.81	1,605.63	1985	310.00	414.10
1968[5]	385.81	1,529.89	1986	400.00	520.54
1969[5]	374.79	1,414.98	1987	400.00	504.40
1970[5]	374.79	1,342.63	1988	400.00	485.47
1971[5]	352.74	1,198.93	1989[7]	540.00	627.59
1972[5]	352.74	1,146.40	1990[7]	540.00	601.01
1973[5]	352.74	1,077.01	1991[7]	540.00	579.03
1974[5]	352.74	990.66	1992[7]	540.00	563.23
1975[5]	352.74	904.07	1993[7]	540.00	551.37
1976[5]	352.74	850.49	1994[7]	540.00	540.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from 1-5 pound metal ingot prices.

[7]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Neodymium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	420.00	2,068.83	1977[5]	220.46	497.32
1960[3]	420.00	2,037.00	1978[5]	220.46	461.03
1961[3]	420.00	2,013.76	1979	250.00	481.30
1962[3]	420.00	1,968.85	1980	260.00	457.27
1963[4]	385.81	1,788.62	1981	260.00	415.54
1964[5]	348.33	1,585.72	1982	260.00	391.24
1965[6]	370.38	1,644.52	1983	260.00	375.99
1966[5]	330.69	1,418.38	1984	260.00	360.29
1967[5]	253.53	1,055.13	1985	260.00	347.31
1968[5]	253.53	1,005.36	1986	280.00	364.38
1969[5]	220.46	832.34	1987	280.00	353.08
1970[5]	242.51	868.76	1988	280.00	339.83
1971[5]	220.46	749.33	1989[7]	340.00	395.15
1972[5]	220.46	716.50	1990[7]	340.00	378.41
1973[5]	220.46	673.13	1991[7]	340.00	364.57
1974[5]	220.46	619.16	1992[7]	340.00	354.62
1975[5]	220.46	565.05	1993[7]	340.00	347.16
1976[5]	220.46	531.55	1994[7]	340.00	340.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from 1-5 pound metal ingot prices.

[7]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Samarium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	440.00	2,167.34	1977[5]	297.62	671.38
1960[3]	440.00	2,134.00	1978[5]	297.62	622.39
1961[3]	440.00	2,109.66	1979	280.00	539.05
1962[3]	440.00	2,062.60	1980	300.00	527.62
1963[4]	396.83	1,839.73	1981	330.00	527.41
1964[5]	407.86	1,856.70	1982	330.00	496.58
1965[6]	687.84	3,054.12	1983	330.00	477.21
1966[7]	485.02	2,080.29	1984	330.00	457.29
1967[5]	352.74	1,468.00	1985	330.00	440.82
1968[5]	352.74	1,398.76	1986	395.00	514.03
1969[5]	308.65	1,165.28	1987	395.00	498.10
1970[5]	319.67	1,145.18	1988	395.00	479.40
1971[5]	297.62	1,011.60	1989[8]	395.00	459.07
1972[5]	297.62	967.28	1990[8]	340.00	378.41
1973[5]	297.62	908.73	1991[8]	340.00	364.57
1974[6]	297.62	835.87	1992[8]	300.00	312.90
1975[5]	297.62	762.81	1993[8]	300.00	306.32
1976[5]	297.62	717.60	1994[8]	300.00	300.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from "over 1 pound" metal ingot prices.

[7]Prices converted from 1-5 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Europium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	9,250.00	45,563.48	1977[7]	5,952.48	13,427.69
1960[3]	9,250.00	44,862.50	1978[7]	5,952.48	12,447.89
1961[3]	9,250.00	44,350.76	1979	6,500.00	12,513.74
1962[3]	9,250.00	43,361.52	1980	7,000.00	12,311.02
1963[4]	3,306.93	15,331.04	1981	7,500.00	11,986.69
1964[5]	4,645.14	21,146.29	1982	7,500.00	11,285.80
1965[6]	11,023.11	48,944.17	1983	7,500.00	10,845.76
1966[6]	11,023.11	47,279.41	1984	7,500.00	10,392.86
1967[7]	7,936.64	33,030.05	1985	7,500.00	10,018.54
1968[7]	7,936.64	31,472.03	1986	7,600.00	9,890.20
1969[7]	7,054.79	26,635.01	1987	7,600.00	9,583.60
1970[7]	7,054.79	25,272.99	1988	7,600.00	9,223.87
1971[7]	5,952.48	20,232.02	1989[8]	7,600.00	8,832.81
1972[7]	5,952.48	19,345.56	1990[8]	7,600.00	8,458.61
1973[7]	5,952.48	18,174.52	1991[8]	7,600.00	8,149.32
1974[7]	5,952.48	16,717.32	1992[8]	7,600.00	7,926.88
1975[7]	5,952.48	15,256.26	1993[8]	7,600.00	7,760.00
1976[7]	5,952.48	14,351.97	1994[8]	7,600.00	7,600.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 1-2 pound metal ingot prices.

[6]Prices converted from 1-5 pound metal ingot prices.

[7]Prices converted from 2-10 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Gadolinium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	730.00	3,595.82	1977[5]	462.97	1,044.38
1960[3]	730.00	3,540.50	1978[5]	462.97	968.17
1961[3]	730.00	3,500.11	1979	430.00	827.83
1962[3]	730.00	3,422.04	1980	440.00	773.84
1963[4]	462.97	2,146.35	1981	485.00	775.14
1964[5]	568.79	2,589.34	1982	485.00	729.82
1965[6]	537.93	2,388.48	1983	485.00	701.36
1966[7]	551.16	2,363.97	1984	485.00	672.07
1967[5]	507.06	2,110.25	1985	485.00	647.87
1968[5]	507.06	2,010.71	1986	500.00	650.67
1969[5]	485.02	1,831.16	1987	500.00	630.50
1970[5]	485.02	1,737.52	1988	500.00	606.83
1971[5]	462.97	1,573.60	1989[8]	500.00	581.11
1972[5]	462.97	1,504.65	1990[8]	500.00	556.49
1973[5]	462.97	1,413.57	1991[8]	500.00	536.14
1974[5]	462.97	1,300.24	1992[8]	500.00	521.51
1975[5]	462.97	1,186.60	1993[8]	500.00	510.53
1976[5]	462.97	1,116.26	1994[8]	500.00	500.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from "over 1 pound" metal ingot prices.

[7]Prices converted from 1-5 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Terbium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	3,750.00	18,471.68	1977[8]	1,807.79	4,078.04
1960[3]	3,750.00	18,187.50	1978[8]	1,807.79	3,780.47
1961[3]	3,750.00	17,980.04	1979	2,000.00	3,850.38
1962[3]	3,750.00	17,579.00	1980	2,300.00	4,045.05
1963[4]	2,314.85	10,731.73	1981	2,800.00	4,475.03
1964[5]	2,843.96	12,946.71	1982	2,800.00	4,213.37
1965[6]	2,411.86	10,708.99	1983	2,800.00	4,049.08
1966[7]	2,425.08	10,401.47	1984	2,800.00	3,880.00
1967[8]	1,895.98	7,890.51	1985	2,800.00	3,740.25
1968[8]	1,895.98	7,518.32	1986	2,800.00	3,643.76
1969[8]	1,543.24	5,826.41	1987	2,800.00	3,530.80
1970[8]	1,543.24	5,528.47	1988	2,800.00	3,398.27
1971[8]	1,543.24	5,245.34	1989[9]	2,800.00	3,254.19
1972[8]	1,543.24	5,015.52	1990[9]	2,800.00	3,116.33
1973[8]	1,543.24	4,711.91	1991[9]	2,800.00	3,002.38
1974[8]	1,807.79	5,077.11	1992[9]	2,800.00	2,920.43
1975[8]	1,807.79	4,633.38	1993[9]	2,800.00	2,858.95
1976[8]	1,807.79	4,358.75	1994[9]	2,800.00	2,800.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Econ Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 1-2 pound metal ingot prices.

[6]Prices converted from "over 1 pound" metal ingot prices.

[7]Prices converted from 1-5 pound metal ingot prices.

[8]Prices converted from 2-10 pound metal ingot prices.

[9]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Dysprosium Metal Prices

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	730.00	3,595.82	1977[5]	264.55	596.79
1960[3]	730.00	3,540.50	1978[5]	264.55	553.24
1961[3]	730.00	3,500.11	1979	270.00	519.80
1962[3]	730.00	3,422.04	1980	300.00	527.62
1963[4]	661.39	3,066.21	1981	300.00	479.47
1964[5]	526.90	2,398.65	1982	300.00	451.43
1965[6]	559.97	2,486.36	1983	300.00	433.83
1966[7]	275.58	1,181.99	1984	300.00	415.71
1967[5]	341.72	1,422.13	1985	300.00	400.74
1968[5]	341.72	1,355.05	1986	630.00	819.85
1969[5]	308.65	1,165.28	1987	630.00	794.43
1970[5]	308.65	1,105.69	1988	630.00	764.61
1971[5]	264.55	899.20	1989[8]	500.00	581.11
1972[5]	264.55	859.80	1990[8]	500.00	556.49
1973[5]	264.55	807.76	1991[8]	500.00	536.14
1974[5]	264.55	742.99	1992[8]	500.00	521.51
1975[5]	264.55	678.06	1993[8]	500.00	510.53
1976[5]	264.55	637.87	1994[8]	500.00	500.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from "over 1 pound" metal ingot prices.

[7]Prices converted from 1-5 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Holmium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	730.00	3,595.82	1977[5]	606.27	1,367.64
1960[3]	730.00	3,540.50	1978[5]	606.27	1,267.84
1961[3]	730.00	3,500.11	1979	1,100.00	2,117.71
1962[3]	730.00	3,422.04	1980	1,400.00	2,462.20
1963[4]	661.39	3,066.21	1981	1,600.00	2,557.16
1964[5]	897.28	4,084.74	1982	1,600.00	2,407.64
1965[6]	1,080.27	4,796.53	1983	1,600.00	2,313.76
1966[7]	992.08	4,255.15	1984	1,600.00	2,217.14
1967[5]	815.71	3,394.76	1985	1,600.00	2,137.29
1968[5]	815.71	3,234.63	1986	1,600.00	2,082.15
1969[5]	628.32	2,372.18	1987	1,600.00	2,017.60
1970[5]	628.32	2,250.88	1988	1,600.00	1,941.87
1971[5]	606.27	2,060.67	1989[8]	1,600.00	1,859.54
1972[5]	606.27	1,970.38	1990[8]	1,400.00	1,558.16
1973[5]	606.27	1,851.11	1991[8]	1,400.00	1,501.19
1974[5]	606.27	1,702.69	1992[8]	1,400.00	1,460.22
1975[5]	606.27	1,553.88	1993[8]	1,400.00	1,429.47
1976[5]	606.27	1,461.77	1994[8]	1,400.00	1,400.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from "over 1 pound" metal ingot prices.

[7]Prices converted from 1-5 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Erbium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	730.00	3,595.82	1977[5]	308.65	696.25
1960[3]	730.00	3,540.50	1978[5]	308.65	645.45
1961[3]	730.00	3,500.11	1979	450.00	866.34
1962[3]	730.00	3,422.04	1980	530.00	932.12
1963[4]	661.39	3,066.21	1981	650.00	1,038.85
1964[5]	632.73	2,880.39	1982	650.00	978.10
1965[6]	694.46	3,083.48	1983	650.00	939.97
1966[7]	595.25	2,553.09	1984	650.00	900.71
1967[5]	396.83	1,651.50	1985	650.00	868.27
1968[5]	396.83	1,573.60	1986	725.00	943.47
1969[5]	352.74	1,331.75	1987	725.00	914.23
1970[5]	683.43	2,448.32	1988	725.00	879.91
1971[5]	308.65	1,049.07	1989[8]	725.00	842.60
1972[5]	308.65	1,003.10	1990[8]	725.00	806.91
1973[5]	308.65	942.38	1991[8]	725.00	777.40
1974[5]	308.65	866.82	1992[8]	725.00	756.18
1975[5]	308.65	791.07	1993[8]	725.00	740.26
1976[5]	308.65	744.18	1994[8]	725.00	725.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from "over 1 pound" metal ingot prices.

[7]Prices converted from 1-5 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Thulium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	4,620.00	22,757.11	1977[7]	5,291.09	11,935.72
1960[3]	4,620.00	22,407.00	1978[7]	5,291.09	11,064.79
1961[3]	4,620.00	22,151.41	1979	7,000.00	13,476.34
1962[3]	4,620.00	21,657.32	1980	6,900.00	12,135.15
1963[4]	8,377.57	38,838.64	1981	8,000.00	12,785.80
1964[5]	12,387.77	56,393.44	1982	8,000.00	12,038.19
1965[6]	8,818.49	39,155.34	1983	8,000.00	11,568.81
1966[6]	13,227.74	56,735.29	1984	8,000.00	11,085.71
1967[7]	8,818.49	36,700.05	1985	8,000.00	10,686.44
1968[7]	8,818.49	34,968.92	1986	8,000.00	10,410.73
1969[7]	6,062.71	22,889.46	1987	8,000.00	10,088.00
1970[7]	6,062.71	21,718.98	1988	8,000.00	9,709.34
1971[7]	5,291.09	17,984.02	1989[8]	8,000.00	9,297.70
1972[7]	5,291.09	17,196.06	1990[8]	6,500.00	7,234.33
1973[7]	5,291.09	16,155.13	1991[8]	6,500.00	6,969.81
1974[7]	5,291.09	14,859.84	1992[8]	6,500.00	6,779.57
1975[7]	5,291.09	13,561.12	1993[8]	6,500.00	6,636.84
1976[7]	5,291.09	12,757.30	1994[8]	6,500.00	6,500.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 1-2 pound metal ingot prices.

[6]Prices converted from 1-25 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[7]Prices converted from 2-10 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Ytterbium Metal Prices[1]

(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	1,260.00	6,206.48	1977[5]	507.06	1,143.84
1960[3]	1,260.00	6,111.00	1978[5]	507.06	1,060.38
1961[3]	1,260.00	6,041.29	1979	720.00	1,386.14
1962[3]	1,260.00	5,906.54	1980	825.00	1,450.94
1963[4]	1,047.20	4,854.83	1981	875.00	1,398.45
1964[5]	654.77	2,980.75	1982	875.00	1,316.68
1965[6]	994.28	4,414.76	1983	875.00	1,265.34
1966[7]	903.90	3,876.91	1984	875.00	1,212.50
1967[5]	573.20	2,385.50	1985	875.00	1,168.83
1968[5]	573.20	2,272.98	1986	1,000.00	1,301.34
1969[5]	529.11	1,997.63	1987	1,000.00	1,261.00
1970[5]	628.32	2,250.88	1988	1,000.00	1,213.67
1971[5]	507.06	1,723.47	1989[8]	1,000.00	1,162.21
1972[5]	507.06	1,647.96	1990[8]	1,200.00	1,335.57
1973[5]	507.06	1,548.20	1991[8]	1,200.00	1,286.73
1974[5]	507.06	1,424.07	1992[8]	1,200.00	1,251.61
1975[5]	507.06	1,299.61	1993[8]	1,200.00	1,225.26
1976[5]	507.06	1,222.57	1994[8]	1,200.00	1,200.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 2-10 pound metal ingot prices.

[6]Prices converted from "over 1 pound" metal ingot prices.

[7]Prices converted from 1-5 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

Lutetium Metal Prices[1]
(Yearend prices in U.S. dollars per kilogram)

Year	Price	Based on constant 1994 dollars[2]	Year	Price	Based on constant 1994 dollars[2]
1959[3]	8,580.00	42,263.20	1977[7]	12,125.42	27,352.70
1960[3]	8,580.00	41,613.00	1978[7]	12,125.42	25,356.82
1961[3]	8,580.00	41,138.33	1979	13,200.00	25,412.52
1962[3]	8,580.00	40,220.74	1980	12,900.00	22,687.45
1963[4]	9,369.65	43,437.95	1981	14,200.00	22,694.80
1964[5]	14,550.51	66,238.96	1982	14,200.00	21,367.78
1965[5]	14,550.51	64,606.31	1983	14,200.00	20,534.63
1966[5]	17,636.98	75,647.05	1984	14,200.00	19,677.14
1967[6]	16,534.67	68,812.60	1985	14,200.00	18,968.43
1968[6]	16,534.67	65,566.72	1986	14,200.00	18,479.05
1969[6]	14,330.05	54,102.36	1987	14,200.00	17,906.20
1970[6]	14,330.05	51,335.76	1988	14,200.00	17,234.07
1971[6]	12,125.42	41,213.37	1989[8]	14,200.00	16,503.41
1972[6]	12,125.42	39,407.63	1990[8]	13,000.00	14,468.67
1973[6]	12,125.42	37,022.18	1991[8]	13,000.00	13,939.63
1974[7]	12,125.42	34,053.81	1992[8]	13,000.00	13,559.14
1975[7]	12,125.42	31,077.56	1993[8]	13,000.00	13,273.68
1976[7]	12,125.42	29,235.49	1994[8]	13,000.00	13,000.00

[1]Prices from Research Chemicals, Phoenix, AZ. Prices are for metal ingot produced from 99.9% grade oxides, f.o.b. Phoenix, AZ, unless noted elsewhere.

[2]Adjusted for inflation with the implicit price deflators for gross domestic product. (Source: U.S. Department of Commerce, Bureau of Economic Analysis).

[3]Prices converted from 100-450 gram metal ingot prices, 99.9% nominal purity, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[4]Prices converted from 1-4 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[5]Prices converted from 1-2 pound metal ingot prices.

[6]Prices converted from 1-25 pound metal ingot prices, from American Potash & Chemical Corp., f.o.b. West Chicago, IL.

[7]Prices converted from 2-10 pound metal ingot prices.

[8]Prices are for 1-kilogram metal ingots from Rhône-Poulenc Basic Chemicals Co.

prepared until 1963, when Weigel applied reduction of the fluoride [20]. Prices for the rare-earth metals are provided in US dollars on an actual and 1994 constant dollar basis. The constant dollar prices were adjusted for inflation with the implicit price deflators for gross domestic product [21].

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